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ABSTRACT

Although copper is a widespread and useful metal, the process of mining and refining copper can have severe detrimental impacts on humans, plants, and animals. The most serious impacts from copper production are the release of sulphur dioxide and other air pollutants and the poisoning of water supplies. These impacts occur in both the mining and refining processes. The processes create visual scars, cause unnatural noise and vibration, potentially cause land subsidence over underground mines, and create large piles of wasterock above the surface. Mine development, like most development, causes sociological impacts on the communities near the mine. Many of these impacts can be minimized if the company or tribe doing the mining is careful and committed to reducing impacts. It would be wise for tribes with potential copper development on their land to be concerned about impacts, to write reclamation requirements into their leases, to enact tribal air, water, and reclamation codes, and to implement mechanisms to enforce these codes. Baseline studies should be conducted to determine the quality of air, water, soil, and wildlife before mining begins in order to document any reduction in quality. (Author/AH)

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COPPER
Its Environmental Impacts

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NOVEMBER 1980

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INTRODUCTION

Copper is an element both valuable to our health and universal in our lifestyle. It has been in use since prehistoric times and has been part of our environment and ecosystem in varying concentrations.[1] To ancient civilizations it represented wealth and power in both its aesthetic and practical qualities. Today we are no less dependent upon it than before. Copper has proven to be a vital material in the advance of architecture, science, and technology.[2] This reddish brown metallic element is so vital because it is malleable (capable of being hammered out thin) and an excellent conductor of electricity and heat.[3] In addition, copper is one of the essential trace elements important to the healthy life of many plants and animals. Although it is essential to a healthy life it can prove to be toxic in larger quantities, especially to lower members of the food chain such as fish.[4]

Today copper and its compounds have assumed an extraordinary diversity. Copper is widely used in electrical applications such as electrical wiring. Other uses include water piping, toxins for bacterial life, pigments, paints, insecticides, household utensils, etc. Copper's wide variety of uses not only reinforces our dependence upon it, it also ensures its universal presence in our environment.[5]

Copper, like the majority of earth's precious resources, has retained its "most wanted" status on the list of the earth's elements. Copper is mined like lead, coal, and other mined elements. The mining produces the usual detrimental impacts too, such as visual impacts, air and water pollution, subsidence, nuisance, health impacts, and other environmental problems. Before discussing these present day environmental impacts a little bit of mining history will be discussed.

Historical Review

Believe it or not, as early as the sixteenth century the negative impacts of the mining industry were described in the world's first mining textbook, 'De Re Metallica,' by George Agricola in 1556. Agricola stated:

> "...the strongest argument of the detractors is that the fields are devastated by mining operation...the woods and groves are down, for there is a need of an endless amount of wood for timbers, machines, and the smeltings of metals. And when the woods and groves are felled, then are exterminated the beasts and birds, very many of which furnish a pleasant and agreeable food for man. Further, when the ores are washed, the water which has been used poisons the brooks and streams, and either destroys the fish or drives them away. ...Thus, it is said, it is clear to all that there is greater detriment from mining than value of the metal which the mining produces."[6]

One cannot deny that Agricola, a European, had an excellent insight into the environmental impacts of mining some four hundred twenty-five years ago. In fact, the previous description could almost have been written today.

The harmful environmental impacts upon the air, land, and water caused by mining have been a concern for a number of years. It is only this past quarter century that any remedial measures have been seriously taken. One early copper smelting operation which operated 70 years ago in this country caused residual metal contamination that is still a problem today.[7]

In 1880, a small mine was purchased by Marcus Daly for thirty thousand dollars in Anaconda, Montana. Two years later a copper deposit was discovered three hundred feet below the mine. Smelters were built one after the other to accommodate all the copper being excavated. It was soon discovered that the amount of copper mined far exceeded the capacity of these smelters, and an even larger smelter had to be built.[8]

In 1902, the Washoe smelter, capable of processing ten to twelve thousand tons of copper a day, was built. Within months farmers living around the area began to notice peculiar symptoms of disease, such as jaundice, in their livestock. These symptoms were only relieved once the animals were removed from the area.[9]

By November of that year several hundred carcasses of horses, cows, and sheep lay scattered throughout the area within a hundred miles. The reason for this occurence was not known until two chemistry professors hired by the local farmers examined the soil, vegetation, and animals. It was discovered that the emissions from the smelter had a very harmful effect upon the area. The state veterinarian diagnosed arsenic poisoning as the cause of death in the animals.[10] No noticeable effects on humans were recorded.

A cash settlement was offered by the company to the farmers. Some took it, some did not. The remedial measure taken by the company was to install a three hundred foot smokestack which only spread the emissions farther.[11]

Finally, in 1907 the farmers were up in arms and raised forty thousand dollars to press their claim that the company was responsible for the nuisance and loss of quality of life which they had experienced since its installation. After four years, a circuit court judge granted the plaintiffs three hundred fifty dollars each in damages. He refused to grant an injunction to them. The reasoning behind the verdict was based on the fact that there were quite a number of people employed by the company who were dependent upon it for their livelihood. The company operation was considered far more important to the region than the agriculture despite the harmful impacts it caused to the surrounding area.[12]

Early copper mining and smelting operations had quite severe impacts on the environment. Large smelters with poorly controlled emissions of particulates proved disastrous to the soil, vegetation, and air. As for how it affected the water in the Anaconda area, tailings discharges were reported up to a distance of a hundred miles away.[13]

The Situation Today

Present day smelters, although they have a much greater efficiency, still suffer from poor pollution controls.[14] What it boils down to is simply economics. Pollution controls and methods are not economically in the best interests of a mining company. The same reasoning the court judge used some seventy years ago still applies today.

In 1978-1979 the copper mining industry came out of one of the worst copper recessions in its mining history. Although it is now enjoying record prices and profits, during the recession of the copper market a few copper companies threatened to close mines and smelters down. The reasoning: high labor cost and prohibitive environmental regulations. One such company, Kennecott Copper Corporation, the nation's largest copper company, laid off some workers and shut down some plants. The company called for the dismantling of environmental controls and an end to wage increases for its workers. Even though the market is stable now, Kennecott still threatens to close some of its smelters if environmental regulations get stricter.[15]

Another example of economics versus environment is a smelter in Tacoma, Washington, owned by ASARCO. The plant was exceeding recently lowered federal and local sulphur dioxide emission regulations, and a 1970-71 study had shown the rate of lung cancer among smelter workers to be 3 to 4 times normal rates. The cause of the cancer has been attributed to the high levels of arsenic trioxide inside the plant which had previously been thought to be harmless. Two of the federal government's most formidable regulatory agencies, OSHA (Occupational Safety and Health Administration) and EPA (Environmental Protection Agency), and two other local authorities ordered smelter officials to reduce pollution both inside and outside the smelter. They wanted the release of sulphur dioxide and arsenic to be severely restricted. The cost of complying with the regulations would approach one hundred and eighty million dollars. The cost of closing the facility would be comparable to the cost of installing the wanted pollution controls. ASARCO has suspended the refinery part of the operation so far. The company will decide in the near future whether it will completely close down the operation or not. It all depends on how the copper market fares.[16]

THE COPPER MINING PROCESS

The copper mining process involves three phases - exploration, development, and production - before the copper is ready for commercial use.

Exploration

The initial phase in the mining process begins with the exploration for the metal. This is usually carried out by prospecting the area in airplanes with magnetic sensors. These sensors are used to pinpoint the area where the ore body may be located. After the ore body area is found the copper company may drill test holes to precisely locate this ore body. Before this is done the clearing and building of access roads must be carried out. Construction of drilling sites and shaft sites and bulk sampling are also required in this phase.[17]

When the bulk ore sample is taken from the drilled test hole, it is then processed and refined to determine the quantity and quality of the metal ore body. From the collected data the prospective copper company will decide whether it is economically feasible for them to mine the ore body.[18]

Development

If mining is feasible and the mining plans are worked out, the development phase of the process will commence. This phase consists of building the mine and the concentrating, metal extraction, and refining facilities. Areas for stockpiling ore, concentrate, wasterock, slag, and tailings basins are also prepared during this phase. The development phase may last several years, and during these years it can cause harmful environmental impacts in the surrounding area such as erosion, leaching, seepage, dust, and mine water runoff.[19]

Production

The last phase, production, includes mining, milling, smelting, and refining before the copper is ready for use.

The first stage of this phase is the mining of the metal. Copper is usually obtained either by open-pit or underground mining. In open-pit mining surface drilling, blasting, loading, and hauling will occur. In underground mining several methods may be used depending on the size, shape, and depth of the ore body. Block caving, room and pillars, and cut and fill methods are usually utilized.[20]

The next stage is the milling of the copper ore, when the ore is crushed and ground into a finely textured powder. The powder is then concentrated by a flotation process.[21]

In the flotation process the copper and nickel sulfide minerals are separated from the wasterock. This is done by a physical separation where chemicals are added to the ore slurry to modify the mineral surfaces. These chemicals selectively change the appropriate mineral surface so that the minerals stick to air bubbles and then float to the surface of the water where they can be removed. Because each metal behaves differently with the added chemical, they can thus be removed independently of each other. The copper concentrate is then filtered and dried to remove any excess water. The tailings (residual waste matter) from this process are collected and deposited in the designated basin areas. After all of this is completed the copper concentrate is ready for the next stage.[22]

In the smelting stage the copper concentrate is roasted to remove most of the sulfur. It is then melted in a reverberatory furnace where a copper "matte" is produced. The matte next goes into a converter furnace where it is produced into a blister copper with a purity of some ninety-nine percent.[23]

Finally, the blister copper goes into the refining stage, where any impurities that may still be present are removed. This may be carried out by three methods: through a refining furnace, electrolytic plating, and electro-winning. All three of these methods will remove virtually all of the remaining impurities. After the completion of this stage the copper is ready to be used.[24]

ENVIRONMENTAL IMPACTS

What are harmful environmental impacts? Basically, they are everything related to reducing the quality of life and disrupting normal human activity.[25] In the copper mining industry this includes visual impact, air and water pollution, waste disposal problems, and other impact areas. In order to assess and remedy these environmental problems one should:

(a) Describe the nature and measure the extent of the impact.

(b) Define acceptable standards and criteria against which to compare the impacts.

(c) Compare the measured impact with the standards.

(d) Execute remedial measures to reduce the impact to conform with acceptable standards.[26]

Visual Impacts

Mining operations always create a visible scar on the land. Open pit mining causes especially severe visual impacts. Large areas of land are cleared of trees and any surface plant growth, the "overburden", (the layer of soil above the ore), is scraped away and an immense pit is created. Even underground mines require a cluster of surface buildings, and the milling process produces the inevitable heaps of waste rock, or tailings. The copper refining process leaves leach dumps, or heaps of acid-bleached rock where no vegetation can grow, and large pools of discolored, contaminated water.[27] To almost anyone, these things look ugly.

Part of the reason mining operations look so ugly is because they often expose rock that is of a different color from the surrounding scenery.[28] The contrast in colors is visible from far away. Also, mine buildings are often covered with dust and dirt on the outside, creating a dilapidated appearance.

Air Pollution

The most significant impact from copper mining and refining is air pollution. Air pollution has been one of the most significant problems plaguing man for over the past seven hundred years.[29] Copper mining produces all of the five main air pollutants: carbon monoxide (CO), hydrocarbon (HC), nitrogen oxide (NOx), sulphur dioxide (SO_2), and particulates.[30]

Sulphur dioxide is the most abundant pollution produced in copper smelting and the most problematic. It is highly destructive, and its effects are felt by humans, animals, and plants. The effect of sulphur dioxide on trees can result in injury to foliage and flowers, acidification of the soil and eventually, it's death. Conifers, which are very sensitive to sulphur dioxide, can even be killed by too much sulphur dioxide.[31]

Among humans, respiratory irritation is the main problem caused by sulphur dioxide. Respiratory irritation can be noticeable at 0.3 parts per

million (ppm) and becomes severe above 0.5 ppm.

Sulphur dioxide affects wildlife by causing acid rain. The sulphur dioxide reacts with moisture in the air to form sulphuric acid, which then falls back to the earth in the form of rain and snow. When acid levels build up in rivers and lakes, fish and aquatic life begin to die. For smelters near cities, the sulphur dioxide emissions simply contribute to the overall air pollution problem, which is known to be a major cause of respiratory disease among urban dwellers.

Particulates, little pieces of dust or liquid vapor that remain in the atmosphere, can cause quite an evident pollution problem. These pollutants should be watched carefully, especially where human health is concerned. Airborne particulates also cause respiratory problems.[32]

Lesser impacts are created from emission of nitrogen oxides, hydrocarbons, and carbon monoxide. Nitrogen oxides are known to contribute to the acid rain problem, which affects all life. Hydrocarbons and carbon monoxide are produced from internal combustion engines such as trucks and mine equipment, and are generally only a problem in enclosed spaces, such as underground mines. The dust and gas eventually settle on the land and water around a copper mine, endangering all living things around it. When wind combines with these emissions, the impact is spread over a wider area.

An example of what emissions can do to a smelter area's vegetation is in an Arizona upland community. The smelter area, once abundant with cactus and grasses, is now bare for 0.5 kilometers outside the area. Numerous skeletons of cactus are still present to testify to this impact. [33]

These airborne pollutants can travel quite far and can affect a water source far from the mining operation. In the La Cloche mountains approximately sixty-five kilometers south of a Sudbury smelter in Canada, the lake showed a ten-fold to one hundred-fold increase in acidity due to the settling of gas and dust emissions.[34]

Air pollution, even at low levels, can cause respiratory illness in humans and can interfere with wildlife, natural vegetation, and can discolor the atmosphere. These impacts would vary according to the location of each specific mine or smelter. It is vital that efficient pollution control devices and methods be installed. Pollution regulations should be strictly enforced at mining operations if the surrounding vegetation, animals, and water sources are to remain clean.

Water Pollution

The second most significant impact area is water, one of life's most abundant and most precious resources. This resource is placed seriously at risk by any mining activities.

Water pollution is generally caused by two types of activities:

(1) The introduction of substances into natural waters causing both physical and/or chemical changes.

(2) Interception or diversion of all or part of a water resource.[35]

What will happen if these two actions occur? First, ecological damages are inevitable. Biological communities that inhabit the water will be altered significantly once a large quantity of mining effluents are introduced. Three potential pollutant sources to watch carefully are mine water, process water, and contaminated surface water. Any run-off or discharge of them will result in the pollution of a water source.

> "Water discharges from mines, concentrators, tailings basins, various dumps, stockpiles, and smelters will possibly contain silt, floatation reagents, and other chemicals, sulphur compounds (acid), heavy metals, heat, and possibly other pollutants. These discharges will have environmental, economic and social impact during all aspects of copper-nickel extraction except exploration and transportation."[36]

Discharge can be extremely dangerous and should always be watched closely.

The first potential water pollutant is mine water. Mine water is the water that seeps into an underground mine from the surface or from underground streams. The water becomes contaminated by any contact with ore, wasterock, overburden, and any dust from the mining operation.[37] It usually contains heavy metals, suspended solids, ammonia, machinery lubricant and other toxic substances.[38] If this mine water escapes or is pumped into a watershed the results can be disastrous.

The other pollutant is process water which during the copper floatation process comes into direct contact with the metal. In this processing stage a large amount of water is used. This water becomes highly contaminated both chemically and physically. The water contains residual quantities of chemicals, wastes, mineral matter and other substances. Process water is usually recycled in a closed system, but it may show up in any tailings basin discharge.[39]

The contamination of surface water will result from contact with any area around the ore handling facility, mill, concentrator, wasterock piles, lean ore piles, tailings ponds, and any other areas where sulfide rock is exposed. Any polluted water discharge or precipitation run-off from the surface will contaminate other water sources.[40]

Another serious factor pertaining to water pollution is leaching and seepage. Leaching occurs when water is filtered through a tailings basin, wasterock pile or ore stockpile. The water, either by rainfall or snow melt permeates into them, acidifies and dissolves toxic ions and then seeps out as surface run-off. It then enters the ground water and contaminates it. From there it is only a small step till it reaches the watershed and contaminates it.[41]

Other sources of water pollutants in the mining operation include sewage, scrubbers, pipelines, and accidental spillage.[42]

Mining pollutants in water can affect man as well as other organisms. Toxicity is rarely experienced by man or higher animals. However, these

toxic substances can be lethal to aquatic life. If the pollution problem is not dealt with, a water source can be rendered lifeless. Problems that occur when copper mining effluents are introduced into an aquatic system are the decreased productivity of the ecosystem, a lowered rate of diversity, and an alteration of the biological community.[43]

The food chain can be altered significantly if one or more stages are contaminated by mining pollutants. If one stage is killed off, the subsequent stages (those which feed on that food source) are deprived of their food. For example, if small animal life in the water is eliminated, fish would be deprived of food and their numbers would be reduced.[44]

Tribes which rely on fish for food should be concerned about nearby copper mining and smelting. They should consider enacting strict water pollution codes and setting up regulatory systems to enforce them. Water quality monitoring before and during a mining and smelting operation is necessary in order to know the extent of the water pollution it causes.

Noise and Vibration

Both noise and vibration are impacts that can be measured and somewhat readily reduced. Although these two impacts are not as significant as the ones described earlier they can prove to be very bothersome to susceptible people. Noise and vibration are potential nuisances when there is a greater intensity, frequency, and duration of the blasting and drilling in the mining operation.[45] Complaints about these impacts generally arise when they interfere with work, communication, recreation, and especially sleep.[46] Industrial noise levels should be checked carefully and also enforced strictly.

If the mining operation is not following the noise level standards, the following steps should be taken to correct the situation:

(a) Measure noise levels at the locations where nuisance is claimed and compare with relevant standards to assess the validity of the claims and the amount of noise reduction required.

(b) Identify the most prominent noise sources.

(c) Consider the remedial measures available and the noise reduction each will yield.

(d) Select the techniques to be used having considered the cost, operational convenience and effectiveness.

(e) Implement the selected control measures.

(f) Measure the reduced noise level to ensure that the nuisance has been removed.[47]

Subsidence

Subsidence usually results from the removal of material from the crust of the earth by underground mining. Subsidence refers to the unplanned sinking or settling of the ground surface, and these occur under the following

circumstances: the geometry of the copper deposit may be too thin, or flat, or too steep or the method of mining may be haphazardly done, without proper support.[48]

Three environmental factors related to subsidence are: the surface land that is affected, the nature of the land use within the mined area and the type and magnitude of the ground movement.[49] Subsidence in the earth's crust is a very complex impact to predict or correct. The reason is due to the unpredictability and complexity of rock mechanics.[50] The best thing to do is to carefully survey the potential area for previous mining activity and any known ground movement.[51] No one wants a mine in an earthquake zone.

Dereliction and Reclamation

The term "dereliction" may have a different meaning in the legal system and in the usage of an everyday person. To the man on the street the land is derelict when the land looks ugly and uncared for. Many aspects of mining such as surface excavation, solid waste disposal dumps, tailings basins and air pollution can sterilize the land. The devastation can reach the point at which the land can never be used again.[52]

The medicine which can cure some of these derelict land areas is reclamation.[53] Reclamation simply means the returning of a derelict site to some use. Financial incentives are now available to assist and encourage the reclamation of land already in the process of being mined. For new mining operations, the conditions under which they are allowed to operate include provisions for restoration thus avoiding the derelict stage all together.[54] Some examples of the end product of reclamation include parks, wildlife refuges, and even some completely revegetated areas.[55] Certain lands may be more reclaimable than others, and studies of reclamation potential should be undertaken before mining begins.

Tribes contemplating copper mining on their reservation should be sure to include reclamation procedures and requirements in the original mining lease. Tribal reclamation codes, specifying the level of reclamation required, the extent of the company's liability for unsuccessful reclamation, and tribal enforcement mechanisms, could also be enacted.

Waste

The last impact, but certainly not the least, is the residual matter called waste which accumulates throughout the mining operation. The amount of waste produced in the mining industry has been increasing dramatically. This is largely due to the increasing world population and increasing demands for the earth's natural rsources.[56] Mining companies must therefore mine for more and more of the earth's natural resources. Certain types of waste can have damaging impacts on the environment, such as tailings which pollute the soil, air, and water. Other types of waste, such as wasterock, have lesser impacts.

Fortunately there are new discoveries made each year on positive uses for waste material thus potentially easing the waste disposal problem. Wasterock can be used in bulk filling. There have even been waste utilization

experiments done with copper tailings. One experiment substituted the tailings for natural sand in glass manufacturing. Unfortunately the presence of iron in the tailings discolored the glass.[57] But they are still trying. Who knows what we will be doing with waste in the future? It might even end up in our gas tanks.

Sociological Impact

Anything new which enters a community is certain to have an effect upon its inhabitants, whether it be a new company, golf course, or even a disco. These new additions to the town would probably prove to be very pleasant for the townspeople. But a new addition can also prove to be devastating to the community, such as a copper company whose wasterock pile threatens to bury the entire town.

This has happened to the tiny town of Lark, Utah. The land upon which this town is situated is owned by Kennecott Copper Corporation, the nation's largest copper company. The company is dispossessing the inhabitants and setting up relocation offices for them. It had been announced earlier that the company was not in the housing business and thus felt no responsibility for the residents. It took an eighty-one year old retired school teacher, who came to the company's stockholder meeting, to change Kennecott's decision to force the relocation of Lark citizens without compensation. Unfortunately, the town will no longer be there, but the families will be somewhat compensated for their forced relocation. There really is no bitterness left in the people of Lark, since the company is legally justified. What remains is the deep sense of loss.[58]

Direct Health Hazards

Under ordinary conditions copper is a benign agent, but when animals or humans are exposed to excessive concentrations of the metal in any of its diverse forms there may be mild to very serious consequences.[59]

Very few studies have been done on the effects of copper exposure on workers. The limited amount of literature available on the effects caused by exposure to copper and its compounds in the industrial world suggest that this metal is not a hazardous industrial substance. However, if any workers are exposed to excess copper concentrations in any of its forms undesirable health effects will result.[60] Miners are not known to be affected by exposure to copper ore itself. Hazards to miners occur because of the air pollution, dust, noise, and other results of the mining process.

Copper dust and fumes usually have an objectionable taste. This is quite fortunate since it can act as a warning mechanism to limit exposure before serious toxic intake can occur.[61]

A worker who is chronically exposed to excessive concentrations of the metal dust and fumes may contract an illness called "metal fume fever". Metal fume fever is an illness which lasts for 24 to 48 hours and is characterized by chills, fever, aching muscles, dryness of the mouth and throat, respiratory congestion, headache, and a feeling of general malaise.[62] For example, fever has been discovered among workers handling copper oxide powder in a paint

factory. It has also been reported by a few men who were exposed to dust produced during the polishing of copper plates. Metal fume fever is not known to produce long term effects.

Four studies have also found an increase in the incidence of lung cancer among workers in copper smelters. These studies suggest that the cancer was caused by exposure to the arsenic trioxide in the dust and fumes inside the smelter, and not caused by exposure to the copper itself.

There has been little research done on the effect of airborne copper dusts or fumes to general populations around smelters. Because of the absence of reports on significant environmental effects from airborne copper. Copper and its compounds as dusts or fumes dispersed into the atmosphere are not now considered hazardous. It may be, however, that future studies will show copper to be more dangerous than we believe it to be today. As Paracelsus has stated, "Poison is in everything and nothing is without poison. Only the dosage makes it either a poison or a remedy."

SUMMARY

Copper is a widespread and useful metal. Its use in daily life is not known to create severe health impacts, but the process of mining and refining copper can have severe detrimental impacts on humans, plants, and animals. Overexposure to copper dust and fumes is known to cause a temporary illness, called "metal fume fever" among industrial workers, and an increased incidence of lung cancer among smelter workers has been attributed to the arsenic trioxide released in the metallurgical process.

The most serious impacts from copper production are the release of sulphur dioxide and other air pollutants and the poisoning of water supplies. These impacts occur in both the mining and the refining processes. These processes also create visual scars on the land, cause unnatural noise and vibration, potentially cause land subsidence over underground mines, and create large piles of wasterock above the surface. Mine development, like almost every form of development, causes sociological impacts on the communities near the mine.

Many of these impacts can be minimized if the company or tribe doing the mining is careful and committed to reducing the impacts. It would be wise for tribes with potential copper development on their lands to be concerned about the impacts, to write reclamation requirements into their leases, to enact tribal air quality, water quality, and reclamation codes, and to implement mechanisms to enforce these codes. Most importantly, tribes should conduct baseline studies to determine the quality of their air, water, soil, and wildlife populations before mining begins in order to document any reduction in the quality of their environment. You've got to know what you have first, before you can know what's been lost.

APPENDIX 1

List of Occupations with Potential Exposure to Copper Dust and Fumes

Asphalt production
Battery production
Copper smelting
Coppersmith work
Electroplating
Metal founding, copper and copper alloys
Fungicide production and handling
Gem coloring
Insecticide production and handling
Welding and soldering
Paint manufacture
Pigment production
Preservative manufacture and handling; hides, railroad ties, rope, wood, etc.
Rayon manufacture
Tanning
Wallpaper manufacture
Water treatment

APPENDIX 2

Indian Reservations near Copper Deposits

Bad River Reservation - Wisconsin
Colorado River Reservation - Arizona
Colville Reservation - Washington
Isleta Pueblo - New Mexico
Jemez Pueblo - New Mexico
Lac Du Flambeau - Wisconsin
Mole Lake Reservation Wisconsin
Papago Reservation - Arizona
Southern Ute Reservation - Colorado
Zia Pueblo - New Mexico

MAJOR COPPER DEPOSITS IN THE UNITED STATES

17 18

From: The United States Geological Survey
Washington, D.C.

BASIC STEPS IN THE COPPER NICKEL PROCESS AND VARIOUS POLLUTION SOURCES AT EACH STEP

POLLUTION SOURCES

MINING

DRILLING AND BLASTING

The ore body is broken up by drilling and blasting.

LOADING

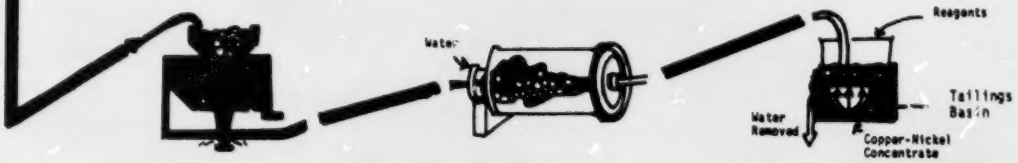
The ore is loaded into cars, trucks and conveyors.

HAULING

Trucks or cars haul the ore to stockpiles or to the mill.

Erosion
Leaching
Seepage
Dust
Minewater
Runoff

MILLING



CRUSHING

The ore is crushed to the size of golf balls.

GRINDING

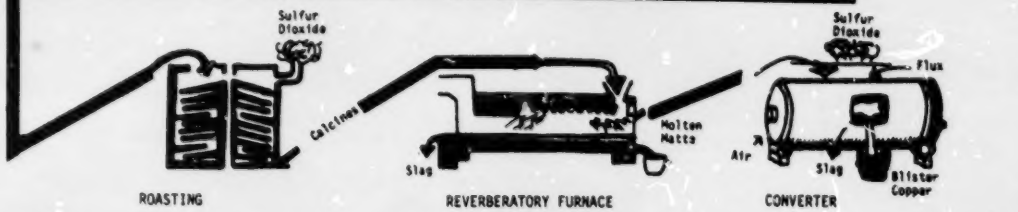
The crushed ore is ground to a powder.

CONCENTRATION - BENEFICIATION

The mineral-bearing particles in powdered ore are concentrated. Separation of copper and nickel may occur here.

Erosion
Leaching
Seepage
Dust
Water Discharges

SMELTING



ROASTING

The copper and nickel concentrates are roasted to remove sulfur.

REVERBERATORY FURNACE

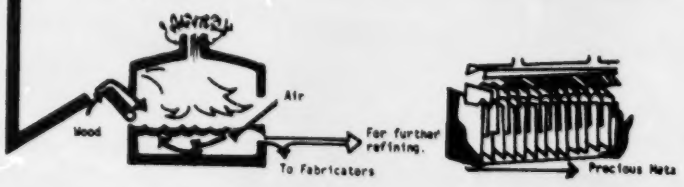
The roasted concentrates are smelted and copper/nickel matte is produced.

CONVERTER

The matte is converted into blister copper, or nickel of 95 - 99% purity.

Gas Emissions
Dust
Leaching
Seepage
Erosion

REFINING



REFINING FURNACE

Blister copper, or nickel is treated in refining furnace.

ELECTROLYTIC REFINING

Copper and nickel are further refined by electrolytic process.

When metals meet the specifications of the fabricators, they are used without further refining.

Electrolytic refining is done if special properties of copper and nickel are desired. It is also u[illegible] to remove and later con[illegible]ate precious metals [illegible] may be present.

From, Water and Copper-Nickel by Michael Rees and Ed Finklea, Minnesota Public Interest Research Group, Minneapolis, 1976.

ENDNOTES

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3. The American Heritage Dictionary, Boston, Houghton-Mifflin Company, 1977, p. 294.

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6. C. G. Down, Environmental Impacts of Mining, London, Applied Sciences Publishers, Ltd., 1977.

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8. Ibid., p. 457.

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11. Ibid., p. 458.

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15. Tom Barry, Copper in New Mexico, Albuquerque, New Mexico People and Energy, New Mexico Power Structure Report, 1980, p. 2.

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18. Ibid., p. 8.

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30. Ibid., p. 59

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32. Ibid., p. 63

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46. Ibid., p. 18.

47. Ibid., p. 162.

48. Ibid., p. 311.

49. Ibid., p. 311.

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51. Ibid., p. 312.

52. Ibid., p. 214.

53. Ibid., p. 213.

54. Ibid., p. 218.

55. Ibid., p. 225.

56. Ibid., p. 20.

57. Ibid., p. 303.

58. Barry Staver, "One of the Mines That Helped Keep Lark, Utah, Alive Will Soon Be Marking Its Grave," People, New York, Time, Inc., September 11, 1978.

59. Nraigu, p. 13.

60. Copper, National Academy of Science, p. 55.

61. Ibid., p. 55.

62. Ibid., p. 56.

63. Ibid., p. 56.

64. Ibid., p. 61.

65. Nraigu, p. 13.

66. Ibid., p. 3.

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